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ABSTRACT

This collection of activities is designed to show how graphing calculators can be used to explore statistics. The activities address such topics as data representation, distributions, and statistical tests. Teaching notes and calculator instructions are included as are blackline masters. (MM)

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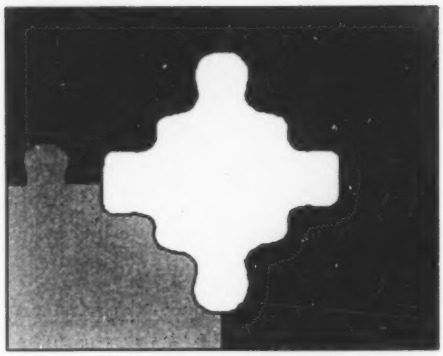

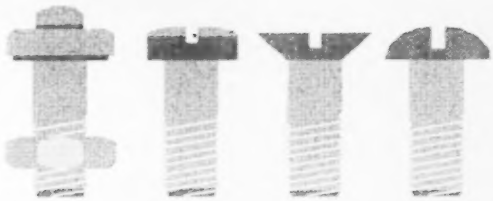

PAPER TOWELS, BASEBALL, PUZZLES, NUTS & BOLTS & THE TI-83Plus STAT TESTS MENU

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TO SEE OR NOT TO SEE, THAT IS THE QUESTION

TEST 2: T-Test **TEST 8: TInterval**

A psychologist is researching different learning styles. Are tasks completed more efficiently with visual clues or textual clues? Student groups attempt to assemble puzzles using hints from a picture, and then a different puzzle just given a word description of the same hints provided in the pictures. The times to complete the puzzles are recorded and analyzed with a matched samples test of hypotheses or confidence interval of the mean difference between matched samples.
The table below is of data collected by students who participated in this lab activity.

GROUP	TIME WITH PICTURE	TIME WITHOUT PICTURE	DIFFERENCES
1	12	3.0	
2	6.4	5.5	
3	12	6.5	
4	12	12	
5	6.8	9.8	
6	5.4	4.4	
7	5.3	2.8	
8	8.9	4.2	
9	9.3	4.0	
10	10.4	6.2	

To use the TI-83 Plus to conduct a **T-Test** on the matched differences:

1. Save the time with picture in a list (say $\mathbf{L_1}$), save the time without picture in $\mathbf{L_2}$, and define $\mathbf{L_3}$ to be the differences $\mathbf{L_1 - L_2}$.
2. Consider the set of differences (d_i, the elements of $\mathbf{L_3}$) as a new data set
3. Press **STAT** and left arrow to **TESTS**
4. Press the 2 key to select **T-Test**
5. Select Inpt:**Data**
6. Set μ_0:**0** to test that there is no difference in completion times between visual and textual clues
7. Set List:$\mathbf{L_3}$; Freq:**1**; and μ: $\neq \mu_0$
8. Select **Calculate**

To use the TI-83 Plus to create a **TInterval** on the mean of the matched differences:

1. Press **STAT** and left arrow to **TESTS**
2. Press the 8 key to select **TInterval**
3. Select Inpt:**Data**
4. For List:$\mathbf{L_3}$ to select the set of differences d_i
5. Set Freq:**1**
6. Set the confidence level C-Level:.95 (this will give a 95% confidence interval)
7. Select **Calculate**

TESTING FOR A QUALITY PRODUCT

TEST 5: 1-PROPZTest

The purpose of this activity is to use a test of hypotheses about a population proportion to make a decision on whether or not a "shipment" of items meets a specified quality level. If the proportion of defective items in a lot is judged to be greater than an acceptable level the lot should be rejected. The students use a scoop to select a sample of items from a can; record the proportion of defectives found in the sample in the table; and use the TI-83 Plus **1-PropZTest** to make the decision to accept or reject the lot. The proportion of defectives in the lot must be judged as ≤ to 5% for the lot to be accepted. After the sampling and testing are completed the instructor will tell the students the actual proportion of defectives in each lot, and the number of Type I and Type II errors that occurred in the activity are counted. In the lab report, the students are to compare the percentage of Type I errors to α, the level of significance used for the tests. The (usually large) percentage of Type II errors observed in this activity is used as an introduction to the next topic in the course, how to compute the value of beta.

To use the TI-83 Plus to conduct a **1-PropZTest**

1. Press the **STAT** key (row 3, col. 3)
2. Press the left arrow to get to **TESTS**
3. Press the 5 key to go to **1-PropZTest**
4. Enter the value of the proportion used in the null hypotheses (in this case .05)
5. For **x**: enter the number of defectives found in the sample
6. For **n:** enter the sample size
7. On the **prop** line arrow to $>p_0$ and press ENTER (this line indicates the inequality in the alternative hypothesis)
8. Arrow down to **Calculate** and press ENTER

The data in the table below were collected by students in the class.

LOT	$\overline{P}$	p-value H_0: p≤0.05	CONCLUSION	p	ERROR
L96A	2/98				
L96B	15/189				
L96C	2/37				
L96D	3/85				
L96E	2/104				
L96F	5/22				

What % of the tests (for the class) resulted in a Type I error? _____

How does this compare to $\alpha = 0.025$?

If there is a large discrepancy between the actual % of Type I errors and α, what explanation can you offer for this?

What % of the tests (for the class) resulted in a Type II error? _____

IS THERE REALLY A HOME TEAM ADVANTAGE?

TEST 6: 2-PropZTest

The objective of this activity is to use sports data downloaded from the Internet to test the hypotheses that the home team has an advantage. A potential website for data is http://www.sports.excite.com/mlb/standings. Computations for the test will be done on the TI-83 Plus using the **2-PropZTest** function, but designing the experiment and providing an appropriate interpretation of the results are left to the students.

(NOTE: The assumption for this test is that the two proportions being compared are from samples selected independently. If it is desired to select more than one team to combine the winning records for a larger sample size, then it is recommended that one team be selected from each of the leagues, one from the AL and one from the NL. Two teams from the same league would not have independent records since a win at home for one team implies a loss away for the other team. There is a much smaller number of games between teams in the different leagues, so the selection process recommended would be more likely to satisfy the independence requirement.)

To Select a random sample using the TI-83 Plus

1. Number the elements of the population from 1 to N.
2. On the TI-83 Plus, press the MATH key (row 4, col. 1)
3. Use the left arrow key to go to PRB (which stands for probability)
4. Select 5: randInt(
5. On the home screen complete the command:
   randInt(1,N,# of elements you want in your sample)
   For example if you had the elements of your population numbered 1 to 72, and you wanted to select 8 elements from the population, then the command would look like this
   randInt(1,72,8)
6. Press Enter to execute the command.
7. Use the right arrow to see the numbers of the elements to be selected in the sample if they go off the screen.

To use the TI-83 Plus to do the computations for the test:

a) Press the **STAT** key and then the left arrow to select **TESTS**
b) Choose #6: **2-PropZTest** by pressing the 6 key.
c) For **x1**, enter the number of games won at home in your sample
d) For **n1**, enter the total number of home games for the team just used in part c, above
e) For **x2**, enter the number of games won away
f) For **n2**, enter the total number of games away
g) On the **prop** line arrow to $>p_0$ and press ENTER (this line indicates the inequality in the alternative hypothesis and H_0: $p_H \leq p_A$ and H_A: $p_H > p_A$)
h) Arrow down to **Calculate** and press ENTER

A TEST OF STRENGTH

TEST C: χ^2 - Test

Learners collected data to test the strength of paper towels. After summarizing the data in a contingency table, a chi-square test of independence is conducted using the TI-83 Plus **χ^2 - Test**. The analysis includes checking the required assumption for a valid test.

Bellow are the tallies for the chi-square test of independence for data for all the groups in the class combined. Use class results in this table to conduct the Chi-Square Test of Independence.

STRENGTH OF TOWEL	BRAND A	BRAND B	BRAND C
WEAK	11	20	3
STRONG	9	0	17

For a Chi-Square test of independence on the TI-83 Plus

a) Press the **MATRIX** key (2nd function on x^{-1} key, row 5, col 1 on TI-83 Plus; row 4, col 2 on TI-83); Left arrow to **EDIT**
b) Select a matrix name, press enter
c) Set the dimensions of the matrix (# rows x # of col.)
d) Press ENTER and enter the observed frequencies of as the elements of matrix A
e) Quit the matrix editor, and press **STAT** for **TESTS**
f) Go to **C: X^2-Test**
g) Confirm the matrix names A and B for the observed and expected frequencies, then **Calculate**

H_0: The srength of the paper towel is independent of the brand.
H_A: The strength and brand are not independent.

A TEST OF STRENGTH REVISTED

TEST F: ANOVA(

The recorded breaking weights (in grams) for the three brands of paper towels are also used to conduct an analysis of variance using the TI-83 Plus calculator.

BRAND A	BRAND B	BRAND C
1724	442	2385
1437	306	1530
1562	204	2138
1228	194	1530
1223	425	1530
1258	300	1267
1262	200	1544
1382	300	1416
1258	200	1404
908	300	1510

HOW to do ANOVA on the TI-83 Plus

1. Enter the data for each of the samples into a separate list: example: if there are three samples list them in L_1, L_2, and L_3
2. Press the **STAT** key and select **TESTS**
3. Arrow up to **F:ANOVA(**
4. On the home screen complete the command with the data lists names ANOVA(L_1,L_2,L_3). Press ENTER

H_0: $\mu_A = \mu_B = \mu_C$

H_A: The mean breaking strengths of the three paper towel brands are not all equal.

DOES PAY REFLECT PERFORMANCE?

TEST E: LinRegTTest (Also **STAT CALC 4:LinReg(ax+b)**)

In this activity students use data obtained from the Internet on executive pay to determine if a company's performance can be used to predict the CEO's compensation. This simple linear regression lab expects the students to use the TI-83 Plus to obtain the scatter diagram, the regression equation, the coefficient of determination, the correlation coefficient, and a test of significance, and to analyze the calculator output in the written lab report.

The website to obtain the total CEO compensation and 1-yr return for 23 companies was http://www.special.pioneerplanet.com/archive/ceopay/docs/197ceo.htm, but may no longer be available, so the data used in the experiment from this website are given below.

Company Name	CEO Total 1996 Compensation (in $1000's)	% 1-year Return
3M Co.	4174	33.2
Norwest	7995	35.2
Medtronic	2311	31.15
First Bank System	14957	40.8
General Mills	1613	15.36
United Health Care	1151	-30.9
Dayton Hudson	5238	53.9
Honeywell	3688	37.4
The St. Paul Cos.	1191	8.7
Green Tree Financial	102449	47.1
ADC Telecommunications	4227	70.7
Northwest Airlines	6701	-23.1
Northern States Power	1510	-0.9
Ceridian	13801	-1.8
St. Jude Medical	2662	-1.4
Ecolab	2947	27.3
ReliaStar Financial	2247	32.9
Bemis	1057	46.7
Hormel Foods	745	3.6
Supervalu	1353	1.73
TCF Financial	2497	33.5
Fastenal	122	8.3
Valspar	901	27.3

SIMPLE LINEAR REGRESSION ON THE TI-83 Plus

To set up your TI-83 Plus to show r, the correlation coefficient, and r^2, the coefficient of determination when you do linear curve fitting, do this:

a) press the 2nd key and the zero key to get to the CATALOG.
b) Press the reciprocal key (row 5, col 1) to go to the D words in the catalog.
c) Arrow down to DiagnosticOn.
d) Press ENTER to put DiagnosticOn on the home screen and ENTER again to execute the command.

Now when you calculate a regression equation r and r^2 will show up in the output. These steps do not have to be repeated each time you do a regression, the calculator is now set to do this until the diagnostics are turned off.

To obtain a scatter diagram, the linear regression equation, correlation coefficient, and coefficient of determination for the down loaded data in Lists COMP and RETRN on the TI-83 Plus follow these steps:

1. Press 2nd and the Y= to get to the STAT PLOT menu
2. Select a STAT PLOT (arrow down), press ENTER.
3. Use the arrow key if necessary to highlight On. Press ENTER to select On
4. Arrow down to Type: and select the scatter plot (first choice in the top row) press ENTER to lock it in.
5. Put appropriate list names in. Decide if we want to predict compensation from 1-year return, or 1-year return from compensation. The list names can be found by pressing the 2nd key and the stat key for LIST; under NAMES select the COMP and RETRN lists.
6. Choose the second Mark (the +):
7. Press the WINDOW key and set the Xmin, Xmax, Ymin, Ymax values to appropriate ones for the x,y data. (Or use a ZOOM 9 which is ZoomStat.)
8. Before pressing the GRAPH key, go to Y= and turn off (or clear) any equations, then press GRAPH to see the scatter diagram
9. Press the STAT key again
10. Use the right arrow key to highlight CALC (for calculate).
11. Select 4:LinReg (ax+b)
12. On the home screen complete the linear regression command by indicating first the list containing the x values, and then the list with the y values. If we are going to predict compensation from one-year return, then our command should look like this LinReg(ax+b) LRETRN,LCOMP,Y_1 This command will paste the regression equation into Y_1.
    - To get Y_1: press VARS key (row 4, col. 4)
    - right arrow to Y-VARS
    - press ENTER for 1: Function
    - press ENTER for Y_1
13. Press ENTER to see the regression coefficients, r (the correlation coefficient), and r^2 (the coefficient of determination).
14. Press GRAPH to see the regression line plotted with the stat plot.
15. Press Y= key to see the regression equation in Y_1

To conduct a t-test for a significant relationship:

1. Press STAT
2. Left arrow to TESTS
3. Up arrow to E:LinRegTTest... press ENTER
4. Enter the appropriate list names for Xlist and Ylist.
5. Leave Freq:1, ≠0, and RegEQ:Y_1 (if that is where you put the regression equation)
6. Arrow down to Calculate
7. Press ENTER

The screen of output will show the test statistic for the t-test $H_0: \beta_1 = 0$ and the p-value for the test. r^2 and r are also included in the output.

To plot the residual plot:

1. The residuals are stored (automatically) into a list when the regression procedure is executed.
2. Press the Y= key and "turn off" Y_1 the regression equation, by placing the cursor on the equal sign and pressing the ENTER key.
3. Arrow up to **Plot1** and press the enter key to "turn off" the scatter diagram.
4. Press 2nd key and the Y= key to get to the stat plots.
5. Press the #2 key to go to **Plot2**
6. Turn on Stat Plot 2
7. Arrow down to **Type:** and highlight the scatter diagram (the first plot in the top row)
8. For **Xlist:** enter the list name of your x-variables.
9. For **Ylist:** press the 2nd key and the STAT key for **LIST**
10. Arrow to the **RESID** list and press ENTER.
11. Select the **Mark** you want.
12. Press the **ZOOM** key and the 9 key for ZoomStat.

The horizontal line through the middle of the graph is the x-axis (where the residuals, or errors, which are plotted on the y-axis) are zero.

*A NOTE ON OUTLIERS:

The "ozone hole" above Antarctica provides the setting for one of the most infamous outliers in recent history. In 1985 three researchers (Farman, Gardinar, and Shanklin) were puzzled by some data gathered by the British Antarctic Survey showing that ozone levels for Antarctica had dropped 10% below normal January levels. The puzzle was why the Nimbus 7 satellite, which had instruments aboard for recording ozone levels, had not recorded similarly low ozone concentrations. When they examined the data from the satellite, it did not take long to realize that the satellite was in fact recording these low levels. It had been doing so for years, but the ozone concentrations recorded by the satellite were so low they were being treated as outliers by a computer program and discarded! The Nimbus 7 satellite has in fact been gathering evidence of low ozone levels since 1976. The damage to our atmosphere caused by chloroflourocarbons went undetected and untreated for up to nine years because outliers were discarded without being examined.

Moral: Don't just toss out outliers, as they may be the most valuable members of a data set.

Does discarding an outlier really help "improve" the model in a regression analysis? Try removing the outlier from the "Pay=Performance?" data set. Has the model changed "for the better"?